RESEARCH HIGHLIGHT

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STRATEGIES FOR REDUCING BUILDING ENERGY USE VIA INNOVATIVE BUILDING ENVELOPE TECHNOLOGIES

INTRODUCTION

Over the past decade, many new technologies have been developed and introduced to the building industry that can recover, generate or save energy at the outer envelope of buildings. Building integrated photovoltaics, high efficiency thermal insulation systems, solariums, solar air preheating systems, and active solar hot water systems are examples of such systems. Not only are these technologies applicable to new buildings, there could be a significant market in the many buildings that already exist. As the stock of buildings ages, building envelope rehabilitation work will become more frequent thereby providing an opportunity to integrate energy saving technologies into renovation plans with acceptable incremental costs. In order to better understand the opportunities to reduce, generate and recovery energy at the building envelope of existing multi-unit residential buildings (MURBs), Canada Mortgage and Housing Corporation initiated a research project to document existing technologies, assess which would be most likely considered by MURB property owners and to evaluate the costs and benefits of selected technologies.

RESEARCH PROGRAM:

The research project involved three tasks. A workshop was held to review current conditions of the apartment building stock and to identify typical performance problems and capital intensive building envelope-related work that property owners are likely to face in the near future. The workshop included representatives from the property management, building envelope consulting and energy-environmental engineering communities. Typical building problems and common repair-rehabilitation projects were identified and, for each, innovative energy saving, reducing or generating technologies were identified that could either solve the problem (or problems) or be easily integrated into the repair work with low incremental costs. In this way, the envelope would be restored and building energy consumption could be reduced. While solving a problem would be the primary motivation for the property owner to undertake the work, the energy savings would be an added benefit.

The project also identified alternative energy technologies that could be implemented as a part of building envelope rehabilitation work on high-rise apartment buildings. This review was largely based on the experience of European retrofit projects as discussed in the International Energy Agency report "Retrofitting Energy Efficiency in Apartment Buildings" (2001). This report examined energy efficiency retrofits in over twenty multi-unit residential buildings. The technologies were discussed at the workshop to determine which would likely be attractive to property owners and managers.

Finally, based on the results of the workshop and technology review, several promising technologies were assessed with respect to their costs and potential energy savings using a computer building energy simulation tool (DOE. 2.1) and a "typical", 1965 era, 16 storey, 187 unit multi-unit residential building located in Toronto, Ontario as a model.

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FINDINGS:

The workshop with the building industry members concluded that there will be ongoing opportunities to integrate energy saving, generation and recovery technologies into the building envelopes of MURBs – largely due to the age of the building stock and the anticipated need for building envelope rehabilitation work. The primary rehabilitation activities where energy saving technologies could be integrated into the buildings include repairing and replacing balconies, masonry façade restoration, and window replacement. Any energy saving measure that can be integrated into such repair work at reasonable incremental costs, or can be installed to reduce or offset routine repair costs, would be favourably viewed by the property management industry. Additionally, energy saving technologies that can also improve the indoor environment, hence occupant health and comfort, within buildings would also be welcome.

The technologies identified as a part of the review were:

- Improved Wall and Roof Insulation
- Window Retrofits
- Sunspaces/Atria (e.g.; enclosed balconies)
- Double-Facade Envelopes
- Building Integrated Photovoltaics (BIPV)
- Solar Ventilation Air Heating (e.g.; Solarwall™)
- Solar Domestic Water Heaters

Upon consideration of the various technologies, two strategies were selected for further study: balcony conversion to sunspaces and solar preheating of ventilation air. These technologies were deemed to be the most attractive to building owners as they can be relatively cost-effective, particularly as a part of work that has to be done to address building performance problems. The costs and benefits of the addition of insulation and the installation of improved windows are relatively well understood and were not explored further in this project. BIPV and solar water heating were deemed too expensive to be of interest to apartment building owners – at least in the near term. The cost and performance of these technologies are expected to improve over time and may be cost effective in the future. Double-façade envelopes are expensive and present many challenges for apartment buildings in terms of noise and smoke control and the inability of tenants to access the outdoors by opening windows.

Solar air heating was deemed to be potentially attractive to building owners as it reduces corridor ventilation system energy use, improves the indoor environment and can be easily integrated into building envelope renewal work. Enclosed balconies were considered viable as they can reduce space heating energy requirements, increase usable space within apartments (seasonally) and can offset balcony and railing repair and replacement costs.

The cost-benefit analysis of the solar air heating and balcony enclosure technologies was undertaken using a computerized energy consumption model of an existing multi-unit residential building located in Toronto, Ontario, Canada. The model was used to evaluate the impact of the technologies on building space heating energy use. Tables 1 and 2 summarize the results of the analysis for both technologies.

Table 1: Modelled Performance of Solar Air Heating System

System Size (% wall coverage)	100%	75 %	50%
Total Area (m^2)	224	168	112
Ventilation Load Offset by Solarwall™ (%)	21%	18%	14%
Annual Energy Savings, if displacing Natural Gas (@ 25¢/m^3)	$3,620	$3,020	$2,280
Annual Energy Savings, if displacing Electricity (@ 7¢/kWh)	$7,140	$5,955	$4,490
Total System Cost	$55,600	$45,700	$35,800
Simple Payback, (natural gas @ 25¢/m^3)	15.4 years	15.1 years	15.7 years
Simple Payback (electricity @ 7¢/kWh)	7.8 years	7.7 years	8.0 years

Table 2: Economics of Enclosing Recessed Balconies – Total Building			
Enclosure Type	**Sunspace**	**Winterized**	**Hi-Perf Winterized**
Annual Energy Savings (for model building	$8,500/year	$4,300/year	$11,500/year
Cost of enclosing balconies	$550,000	$ 650,000	$ 750,000
Reduced Balcony Maintenance	($120,000)	($ 120,000)	($ 120,000)
Reduced Window Replacement	($ 340,000)	($ 340,000)	($ 340,000)
Net Cost	$90,000	$ 190,000	$290,00
Simple Payback	10.5 years	44 years	25 years

For the solar air heating system, it was found that the simple payback of the technology was less than 10 years for the building modeled. The payback could be reduced to less than 5 years if the technology was implemented as part of a larger recladding project. The payback period for the system was relatively insensitive to the physical size of the solar collector. The primary challenge for solar air pre-heating systems would be to overcome the practical and aesthetic problems associated with locating the panels on the exterior walls where solar gains are available.

Three strategies for enclosing balconies were studied: "sunspace" (single pane glazing, seasonal use), "winterized" (double pane glazing, all season use) and "high performance" (double pane glazing c/w low-e coating and argon gas fill, all season use) for both protruding balconies and recessed balconies. Enclosing protruding balconies tended to result in increased space heating energy use because of the increased envelope area. Enclosing recessed balconies not only saves energy but also reduces repair and maintenance costs associated with concrete balconies and steel railings. The payback on the incremental cost is 10 years for the sunspace arrangement and 25 years for the high-performance window arrangement. Although the payback for the latter arrangement is long, it increases the usable floor area of the apartment and provides a desirable amenity where none existed before.

Implications for the Housing Industry

As the stock of MURBs age, there will be more building envelope rehabilitation work performed. This will provide an opportunity to integrate energy saving technologies into building envelopes where it may have been difficult to previously rationalize doing so based on energy cost savings alone. There are many technologies available that can be used to save, recover or generate energy at the building envelope of buildings but operational experience is limited. It was found that the current economics and risk associated with many of the available technologies can undermine their attractiveness to property owners. To increase the likelihood that the technologies are accepted, they must be relatively risk-free, have short (under 5 years) payback periods, be easily (and cost-effectively) implemented as a part of a larger building repair or renewal projects, be able to address other building performance problems or reduce operational expenses associated with building repair and renewal.

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Housing Research at CMHC

Under Part IX of the *National Housing Act*, the Government of Canada provides funds to CMHC to conduct research into the social, economic and technical aspects of housing and related fields, and to undertake the publishing and distribution of the results of this research.

This fact sheet is one of a series intended to inform you of the nature and scope of CMHC's research.

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